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UNITED STATES GOVERNMENT

memorandum

Memorandum
Head, Remote Sensing Section

TO :

Denver, Colorado
DATE: September 3, 1987

FROM : Michael J. Pucherelli, Environmental Biologist

SUBJECT: Colorado River Backwater Mapping for the Glen Canyon Environmental Studies

Applied Sciences Referral Memorandum No. AP-87-4-6

Principal Investigator: Michael J. Pucherelli

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1.0 Introduction

The Colorado River Backwater Habitat Mapping Study presented herein represents a portion of the ongoing Glen Canyon Environmental Studies being performed jointly by several State and Federal agencies. A quantitative backwater analysis was undertaken to support the opinion that backwater habitat for fishes in the Grand Canyon portion of the Colorado River is not affected by controlled releases from Glen Canyon Dam.

Prior to making a final recommendation for operations at Glen Canyon Dam, the Arizona Game and Fish Department requested that a backwater-to-flow relationship study be performed on a select reach of the Colorado River. Subsequently, the approximately 20-river-mile reach from river-mile 52 (Nankoweap Rapid) to river-mile 72 (Unkar Rapid) was selected for analysis.

2.0 Methodology

Aerial photography was acquired by the U.S. Bureau of Reclamation, Remote Sensing Section, for four flows, encompassing four dates over a 14-year period (table 2-1). Each set of photography was then examined for backwaters using an 8X Achromatisch hand lens. Stereoscopic examinations were performed when required, using the Old Delft Scanning Stereoscope II, with variable magnification. All photographs were back-illuminated over a standard light table to enhance clarity of features.

Results of the photointerpretation effort were recorded on mylar sheets overlain directly on the aerial photography. When possible, only the center portion of each photograph was interpreted so that edge distortion could largely be eliminated. Each polygon (backwater) thus

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Identified was then electronically planimetered, using a La SICO model 42P digital readout planimeter to determine area (in acres). Polygons less than 0.01 acre in size were so noted since they could not be accurately planimetered. Such polygons were identified using a template prepared to scale.

Following photointerpretation and area determination, a list indicating backwater number and size was prepared. Data from the list were then used to produce bar graphs showing the following relationships:

- o Total number of backwaters at each flow,
- o Total number of backwaters greater than 0.01 acre,
- o Backwater acreage for each flow, and
- o Indicator lines showing the position of the Little Colorado River in relation to backwater numbers.

Table 2-1. - Description of acquired aerial photography

<u>Date</u>	<u>Range of flows</u>	<u>Type</u>	<u>Scale</u>
6-16-73	6,500-9,800 ft ³ /s	Black and white	1:7200
10-22-84	5,100-8,000 ft ³ /s	Black and white	1:3000
6-7-85	32,300-36,400 ft ³ /s	Color infrared	1:4800
5-20-87	7,900-8,400 ft ³ /s	Color infrared	1:4800

3.0 Results

Backwaters occurring between river-miles 52 and 72 have been quantified for the Colorado River below Glen Canyon Dam. For the purpose of this study, backwaters are defined as areas of water with no flow, but not cut off from the river's edge. It is important to understand, however, that this study reflects numbers and size of backwaters only and makes no attempt to determine the quality parameters necessary to support viable fishery habitat, e.g., depth, temperature, water quality, etc. Backwaters along the river reach studied generally form over sand, gravel, or cobble.

Flows used ranged from a low of 5,100 ft³/s (1984) to a high of 36,400 ft³/s (1985), while total backwater numbers ranged from 38 (1973) to 134 (1987). It should be noted that 1973 photography was at the smallest scale (1:7200) and possessed a high degree of reflectance or glare from the river, making accurate identification and delineation of backwaters difficult.

Figure 3-1 illustrates the total number of backwaters for each year/flow of photography acquired. The highest number of backwaters were observed on the 1987 photography. One hundred thirty-four backwaters were distributed, 59 upstream from the LCR (Little Colorado River) confluence and 75 downstream for the 1987 photography. Similar, but lower values were observed on the 1984 and 1985 photography with 126 and 115 total backwaters, respectively. The distribution of backwaters upstream and downstream of the LCR confluence for these years and flows were 56/70 for 1984 and 71/44 for 1985.

The 1973 photography exhibited the lowest number of backwaters observed with 38 total. Distribution of these backwaters upstream and downstream from the LCR confluence was 26/12, respectively. This set of photography was the smallest scale (1:7200) used for the study.

Occurrence of backwaters upstream and downstream from the LCR confluence is very similar for the 1984 and 1987 data with a 55/71 and 59/75 distribution, respectively. While there were slightly fewer backwaters observed on the 1985 photography, e.g., 115, the distribution relative to the LCR confluence was reversed at 71/44.

Backwater totals can be used to look at pre- and postflooding events in this area. A relatively large flood impacted the study reach in 1983 and high water persisted in 1984. Preflood 1973 data indicate that fewer than 40 backwaters occurred along the study reach. Postflood 1984, 1985, and 1987 backwater totals are consistently in excess of 110 backwaters (fig. 3-1).

Backwaters in excess of 0.01 acre in surface area are a relatively consistent number for the 1984 through 1987 flows (fig. 3-2). These numbers are 1984:74; 1985:89; and 1987:88. In the preflood year of 1973

only 19 backwaters in excess of 0.01 acre were observed. The measurable backwaters occurred very evenly in relation to the LCR confluence for all years of photography except 1973 which had 13/6 upstream/downstream distribution.

Approximate acreages covered by backwater habitat are illustrated on figure 3-3. The 1984 flow regime supported the highest backwater acreage measured at approximately 11.5 acres. Preflood, or the 1973 flow regime provided the least backwater habitat, or approximately 1.5 acres.

4.0 Discussion

It is apparent that larger numbers of backwaters are present in the years 1984, 1985, and 1987 than were present in 1973. The total numbers of backwaters for these 3 years surpass the 1973 total by about three times. Consistent with these data, measurable backwaters (greater than 0.01 acre) are also about three times more common in the years 1984, 1985, and 1987 than they were in 1973.

Surface area covered by backwaters appears to be more variable, but can be related to the flow regime. In 1984, the highest backwater acreage was observed, regressing as flows increased. The lowest surface area coverage occurred in 1973.

Several inferences can be made using the data gathered herein, and include:

- Flooding in 1983 and high water releases in 1984 impacted the river and created backwaters.
- Backwaters have increased nearly threefold over the 1973 number.
- Total backwater numbers have remained relatively consistent from 1984 to 1987, regardless of the flow regime.
- Backwater numbers upstream of the Little Colorado River are approximately equal to the numbers downstream.
- Measurable backwaters have remained relatively consistent in number from 1984 to 1987, regardless of the flow regime.
- The surface area of backwaters increases with decreased flow regime.

In assessing backwater numbers and surface area, the quality of aerial photography used must also be considered. The 1973 photography was the smallest scale used (1:7200) and the clarity was affected by glare from the river surface. The 1987 photography, while at an optimal scale (1:4800), was affected by cloud shadow in some areas and a small gap in

coverage of about 200 yards. Both the 1984 (1:3000) and 1985 (1:4800) photography were clear and sharp.

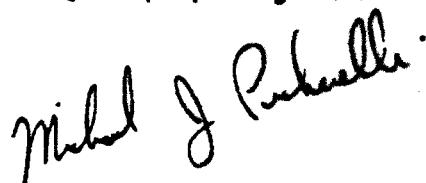
It is doubtful that the scale and quality of the 1973 photography affected the results of this study to any great extent. Perhaps the greatest degree of error resulting from the use of this photography occurs in the surface area measurements, where consistently small polygons must be planimetered.

Quantitative values have been derived from the observation of aerial photography, pertaining to total number, size, and distribution of backwaters along this approximately 20-mile-river reach. It is unknown which backwaters represent the better fisheries habitat, since no qualitative data specific to the reach under consideration, currently exist.

The data generated in this report can be used to identify those areas likely to contain backwater habitat and approximate the number of these habitats occurring at different known flow regimes. Associated field studies, however, must accompany each aerial overflight, so that importance values can be determined. In this manner, the photointerpretation effort can then be coordinated to identify the most important backwater habitat present for the various fish species that utilize them.

Acknowledgments

I commend Mr. Dave Wegner on the excellent job he has done coordinating among the many subteams involved in the Glen Canyon Environmental Studies. I acknowledge the special efforts of Jim Von Loh for interpreting the aerial photographs and assisting in preparing this memorandum.



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D-1524 (Pucherelli)

TOTAL BACKWATERS OBSERVED ON ACQUIRED AERIAL PHOTOGRAPHY

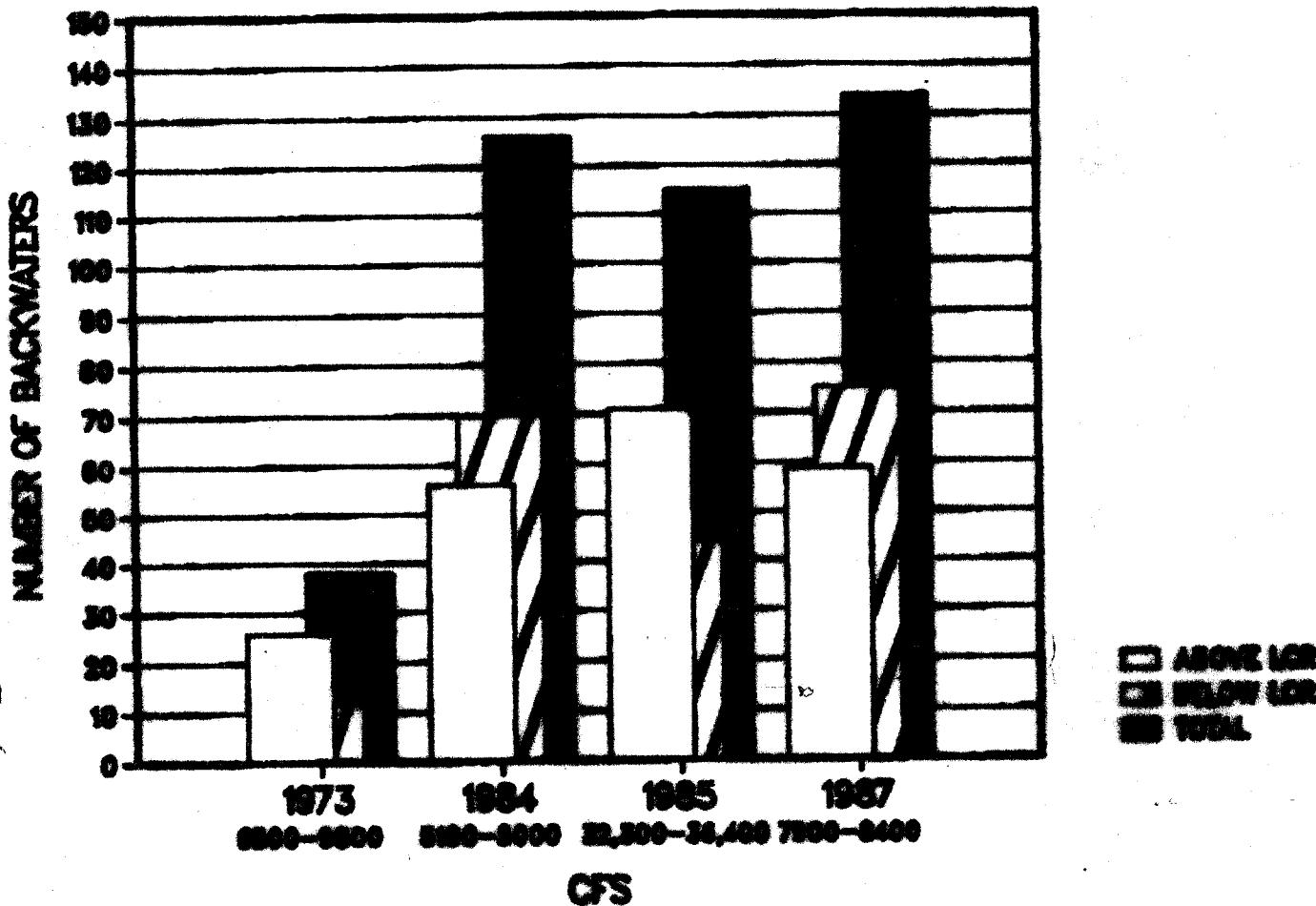


FIGURE 3-1

BACKWATERS GREATER THAN 0.01 ACRES IN SURFACE AREA

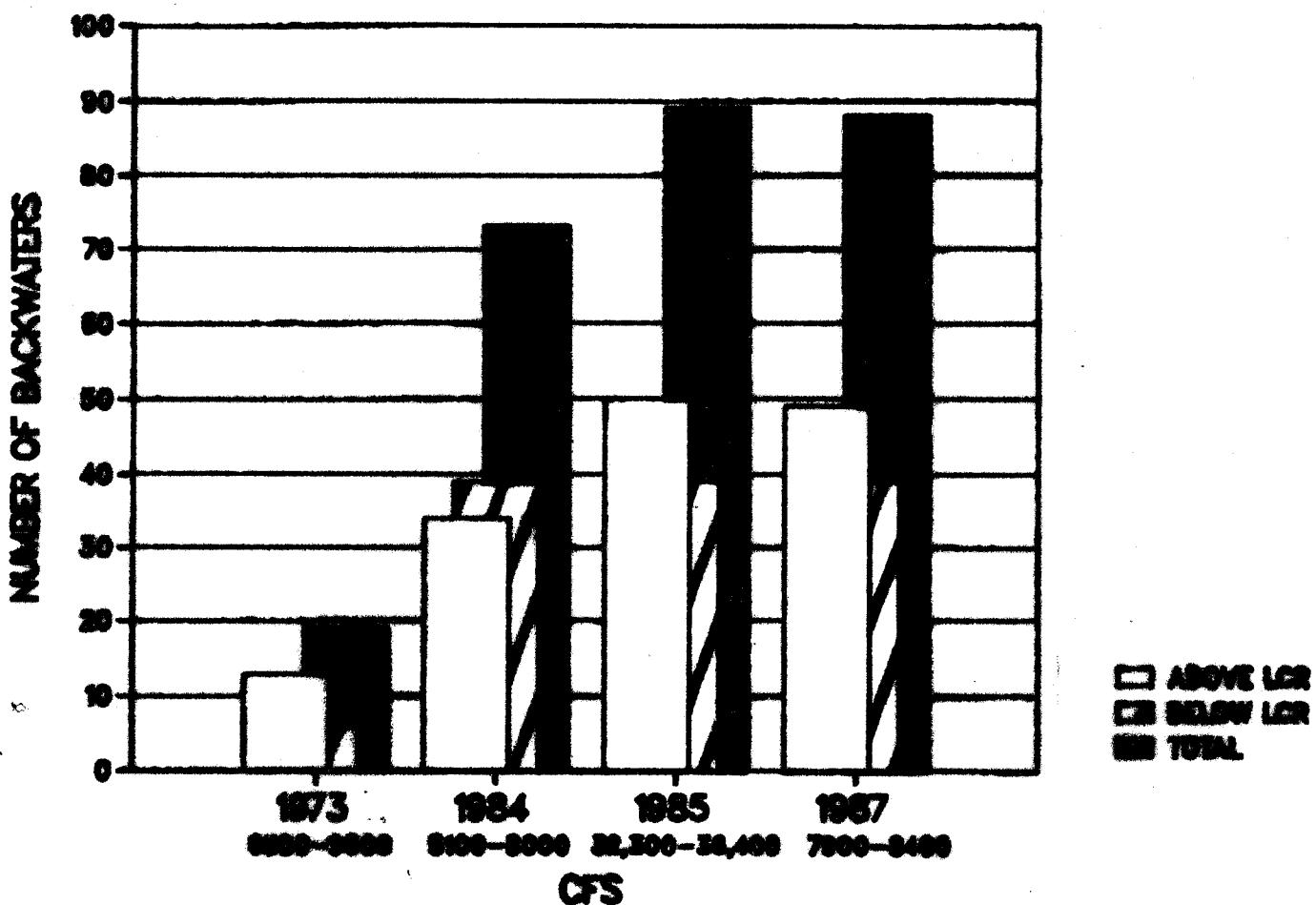


FIGURE 3-2

● APPROXIMATE BACKWATER SURFACE AREA (ACRES)*

* BACKWATERS MEASURING LESS THAN 0.01 ACRES ARE ASSUMED TO BE EQUAL TO 0.1 ACRES

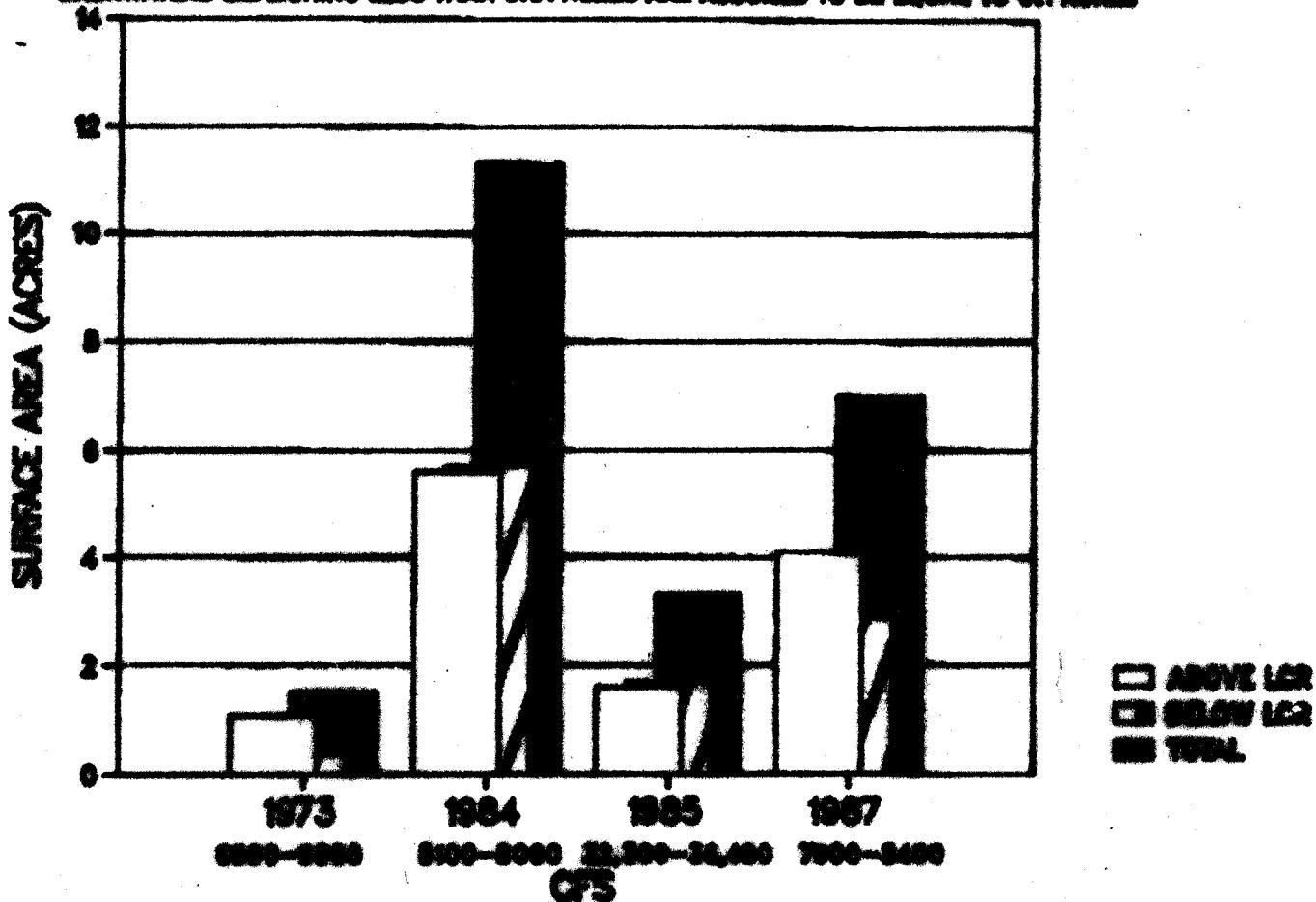


FIGURE 3-3

**APPENDIX A: LIST OF BACKWATERS AND SURFACE AREA, 1973
PHOTOGRAPHY.**

Backwater Number	Acres of Backwater
1)	0.060
2)	<0.01
3)	<0.01
4)	<0.01
5)	0.015
6)	0.050
7)	<0.01
8)	<0.01
9)	<0.01
10)	<0.01
11)	<0.01
12)	0.200
13)	0.050
14)	0.025
15)	<0.01
16)	0.050
17)	0.025
18)	<0.01
19)	0.075
20)	0.025
21)	<0.01
22)	<0.01
23)	0.300
24)	0.075
25)	<0.01
<u>26)</u>	<u>0.025</u>

1.105 acres, N of the LCR (N=North)

27)	<0.01
28)	<0.01
29)	<0.01
30)	0.100
31)	0.050
32)	0.062
33)	0.025
34)	0.050
35)	<0.01
36)	<0.01
37)	0.016
<u>38)</u>	<u><0.01</u>

0.363 acres, S of the LCR (S=South)
1.468 Acres Total

**APPENDIX B: LIST OF BACKWATERS AND SURFACE AREA, 1984
PHOTOGRAPHY.**

Backwater Number	Acres of Backwater	Backwater Number	Acres of Backwater
1)	0.040	49)	0.020
2)	0.268	50)	<0.01
3)	0.112	51)	<0.01
4)	0.408	52)	<0.01
5)	0.016	53)	<0.01
6)	0.180	54)	0.064
7)	0.128	55)	<0.01
8)	0.484	56)	<u>0.020</u>
9)	0.012		
10)	0.296		5.572 acres, N of the LCR
11)	0.128		
12)	<0.01	57)	<0.01
13)	0.598	58)	0.096
14)	<0.01	59)	0.136
15)	<0.01	60)	0.016
16)	0.032	61)	0.024
17)	0.084	62)	<0.01
18)	<0.01	63)	0.028
19)	0.012	64)	0.044
20)	0.016	65)	0.024
21)	<0.01	66)	0.032
22)	<0.01	67)	<0.01
23)	0.180	68)	0.012
24)	0.012	69)	<0.01
25)	<0.01	70)	0.020
26)	<0.01	71)	0.060
27)	<0.01	72)	0.028
28)	<0.01	73)	0.068
29)	0.248	74)	0.036
30)	0.024	75)	0.016
31)	0.124	76)	<0.01
32)	<0.01	77)	0.012
33)	0.028	78)	<0.01
34)	0.052	79)	0.064
35)	0.220	80)	<0.01
36)	0.016	81)	<0.01
37)	0.152	82)	<0.01
38)	0.184	83)	<0.01
39)	0.696	84)	<0.01
40)	0.016	85)	<0.01
41)	0.012	86)	0.148
42)	0.028	87)	<0.01
43)	<0.01	88)	<0.01
44)	0.020	89)	<0.01
45)	0.112	90)	<0.01
46)	0.012	91)	<0.01
47)	0.128	92)	0.208
48)	0.220	93)	0.036

**APPENDIX B: LIST OF BACKWATERS AND SURFACE AREA, 1984
PHOTOGRAPHY. (continued)**

Backwater Number	Acres of Backwater
94)	<0.01
95)	<0.01
96)	0.532
97)	<0.01
98)	<0.01
99)	0.012
100)	0.028
101)	<0.01
102)	0.404
103)	0.028
104)	<0.01
105)	<0.01
106)	2.104
107)	0.920
108)	<0.01
109)	0.036
110)	0.012
111)	<0.01
112)	<0.01
113)	<0.01
114)	<0.01
115)	<0.01
116)	<0.01
117)	0.048
118)	<0.01
119)	<0.01
120)	0.028
121)	<0.01
122)	0.040
123)	<0.01
124)	0.012
125)	<0.01
<u>126)</u>	<u>0.024</u>

5.696 Acres, S of the LCR
11.268 Total Acres

**APPENDIX C: LIST OF BACKWATERS AND SURFACE AREA, 1985
PHOTOGRAPHY.**

Backwater Number	Acres of Backwater	Backwater Number	Acres of Backwater
1)	0.022	49)	0.011
2)	0.011	50)	<0.01
3)	0.066	51)	<0.01
4)	0.022	52)	0.033
5)	<0.01	53)	<0.01
6)	0.011	54)	0.022
7)	0.011	55)	0.022
8)	0.011	56)	0.033
9)	<0.01	57)	0.011
10)	0.033	58)	0.121
11)	<0.01	59)	<0.01
12)	0.011	60)	0.011
13)	<0.01	61)	0.044
14)	0.011	62)	<0.01
15)	0.011	63)	<0.01
16)	<0.01	64)	0.022
17)	0.022	65)	0.022
18)	0.055	66)	<0.01
19)	0.044	67)	0.022
20)	0.022	68)	<0.01
21)	<0.01	69)	<0.01
22)	<0.01	70)	0.022
23)	0.014	71)	0.121
24)	0.014		
25)	0.022	1.646 acres, N of the LCR	
26)	<0.01		
27)	0.022	72)	0.110
28)	0.022	73)	0.012
29)	<0.01	74)	<0.01
30)	<0.01	75)	0.022
31)	0.033	76)	0.033
32)	0.055	77)	0.044
33)	0.033	78)	0.033
34)	0.011	79)	<0.01
35)	0.022	80)	0.066
36)	0.011	81)	0.022
37)	0.022	82)	0.033
38)	0.011	83)	0.022
39)	0.022	84)	0.022
40)	0.022	85)	0.022
41)	0.077	86)	<0.01
42)	0.011	87)	0.011
43)	<0.01	88)	0.022
44)	0.022	89)	0.011
45)	<0.01	90)	0.011
46)	0.066	91)	<0.01
47)	0.033	92)	0.022
48)	0.011	93)	0.022

**APPENDIX C: LIST OF BACKWATERS AND SURFACE AREA, 1985
PHOTOGRAPHY. (continued)**

Backwater Number	Acres of Backwater
94)	0.022
95)	0.022
96)	0.011
97)	0.014
98)	0.022
99)	0.121
100)	0.077
101)	0.011
102)	0.022
103)	0.022
104)	0.044
105)	0.014
106)	0.198
107)	0.099
108)	0.055
109)	0.014
110)	0.110
111)	0.044
112)	0.099
113)	0.022
114)	<0.01
<u>115)</u>	<u>0.055</u>

1.688 acres, S of the LCR

3.334 Acres Total

**APPENDIX D: LIST OF BACKWATERS AND SURFACE AREA, 1987
PHOTOGRAPHY.**

Backwater Number	Acres of Backwater	Backwater Number	Acres of Backwater
1)	0.066	49)	<0.01
2)	0.022	50)	0.022
3)	0.055	51)	0.084
4)	0.033	52)	0.033
5)	<0.01	53)	0.011
6)	0.011	54)	0.044
7)	0.066	55)	<0.01
8)	0.011	56)	0.011
9)	0.022	57)	0.132
10)	0.046	58)	0.022
11)	0.022	59)	0.022
12)	0.022		
13)	0.066		4.058 acres, N of the LCR
14)	0.462		
15)	0.022	60)	0.011
16)	0.946	61)	<0.01
17)	<0.01	62)	0.066
18)	0.077	63)	<0.01
19)	0.022	64)	0.176
20)	0.410	65)	<0.01
21)	0.077	66)	<0.01
22)	0.022	67)	0.011
23)	0.143	68)	0.022
24)	<0.01	69)	<0.01
25)	<0.01	70)	<0.01
26)	0.011	71)	0.011
27)	0.022	72)	0.022
28)	0.066	73)	<0.01
29)	0.022	74)	<0.01
30)	0.066	75)	<0.01
31)	<0.01	76)	0.022
32)	<0.01	77)	<0.01
33)	0.011	78)	0.044
34)	0.022	79)	<0.01
35)	0.011	80)	<0.01
36)	0.110	81)	0.022
37)	0.022	82)	<0.01
38)	0.044	83)	0.022
39)	0.022	84)	0.011
40)	0.011	85)	<0.01
41)	0.022	86)	0.088
42)	<0.01	87)	0.033
43)	<0.01	88)	<0.01
44)	0.011	89)	<0.01
45)	0.022	90)	<0.01
46)	0.033	91)	<0.01
47)	0.022	92)	<0.01
48)	0.022	93)	<0.01
			0.011

**APPENDIX D: LIST OF BACKWATERS AND SURFACE AREA, 1987
PHOTOGRAPHY. (continued)**

Backwater Number	Acres of Backwater
94)	0.011
95)	0.011
96)	0.011
97)	0.022
98)	0.011
99)	<0.01
100)	<0.01
101)	<0.01
102)	0.011
103)	<0.01
104)	<0.01
105)	<0.01
106)	0.011
107)	<0.01
108)	0.088
109)	<0.01
110)	0.066
111)	0.044
112)	<0.01
113)	0.011
114)	0.022
115)	0.022
116)	<0.01
117)	1.232
118)	0.022
119)	0.011
120)	<0.01
121)	0.011
122)	0.022
123)	0.011
124)	0.011
125)	<0.01
126)	<0.01
127)	<0.01
128)	<0.01
129)	0.011
130)	<0.01
131)	0.132
132)	<0.01
133)	0.022
134)	<u>0.033</u>

2.791 acres, S of the LCR

6.849 Acres Total